Improving Survey Efficiency Through the use of Points Sources

M. Rocke[1], C. Schneider[1], E. Marc[1], C. Udengaard[1], H. Flores[1]

[1] TGS

Summary

A growing Geophysical argument for the use of single-element pneumatic points sources has been developing over the last several years. They have been shown to significantly improve the low-frequency signal-to-noise ratio (SNR) on both towed-streamer and ocean bottom node (OBN) surveys, thereby extending the available bandwidth in the recorded data. Udengaard et al (2023) and Shang et al (2023) made separate demonstrations for using the Gemini extended frequency source and the Tuned Pule Source (TPS) respectively as exclusive sources in support of Imaging and FWI model building on sparse OBN surveys in the Gulf of Mexico. Ou et al (2023) documented the use of Gemini as the only source in a full survey application of a dual-vessel, quad-source, Wide Azimuth (WAZ) towed-streamer design in the Eastern Mediterranean.

Field implementations of large point sources thus far, however, have been limited to two sources per vessel mainly due to the perception that this represents the limits of capacity of modern survey vessels. We embarked on field trials over the last six months to understand the feasibility of operating more than two Gemini units concurrently on the same vessel.

Introduction

A comprehensive and growing Geophysical argument for the use of large single-element pneumatic points sources has been developing over the last several years. They have been shown to significantly improve the low-frequency signal-to-noise ratio (SNR) on both towed-streamer and ocean bottom node (OBN) surveys, thereby extending the available bandwidth in the recorded data. Ten Kroode et al (2013) identified four key benefits of improved low frequency SNR, namely greater certainty in FWI model building, higher resolution images, and improved seismic inversion. Udengaard et al (2023) and Shang et al (2023) made separate demonstrations for using the Gemini extended frequency source and the Tuned Pule Source (TPS) respectively as exclusive sources in support of Imaging and FWI model building on sparse OBN surveys in the Gulf of Mexico. Ou et al (2023) documented the use of Gemini as the only source in a full survey application of a dual-vessel, quad-source, Wide Azimuth (WAZ) towed-streamer design in the Eastern Mediterranean.

All field implementations of single-element pneumatic point sources thus far, however, have been limited to two sources per vessel mainly due to the perception that this represents the limits of capacity of modern survey vessels. Several authors (Hager et al 2015, Rocke et al 2018) have discussed the efficiency gains associated with moving from dual source to triple source configurations, and these are equally relevant to point sources. Arguably, any case for using pneumatic point sources as an alternative to airgun arrays should consider the impact to survey efficiency and cost. We embarked on field trials over the last six months to understand the feasibility of operating more than two Gemini units concurrently on the same vessel, and capture metrics intended to form the basis for survey design and feasibility analysis in the future. The results of our testing thus far, which will be presented as part of the proposed talk, suggest that Gemini 8000 in^3 units can be operated in a triple source configuration on most modern seismic survey vessels for a wide range of source geometries.

Method

Our initial hypothesis was informed by the work of Aznar et al (2022) which documented the challenges associated with charging a 26,500 in^3 TPS unit at 1000 psi. The author indicated the theoretical relationship between umbilical dimensions and source fill times for a given compressor pressure and target source pressure. What this relationship highlighted was that transferring air from the vessel to the source becomes increasingly challenging as the source volume increases for dimensions of umbilicals typically in use on seismic survey vessels. In other words, in delivering large volumes of air to the source, the umbilical represents the limiting factor, and not the compressor capacity in a dual source configuration.

While we are not able to reproduce the theoretical values indicated by Aznar et al (2022) exactly, we did observe comparable results in our field tests. Differences between theoretical and field measurements were attributed to the additional influence of variability in back deck plumbing from one vessel to the next. As an example from one extreme outlier case, the constraints placed by outdated back deck plumbing on source fill time meant that one test vessel was suitable for exploration surveys only – where a significant delta between back deck pressure and chamber pressure could be leveraged while triggering shots on time – and would only be suitable for 4D surveys after a relatively minor back deck plumbing upgrade.

Our tests encompassed the three key areas relevant to source refill, total compressor capacity, efficiency of air delivery, and quantifying nominal residual air in source chamber after each shot. Table 1 shows a summary of the results based on an accumulation of tests across four vessels.

		Number of Gemini 8K Sources at 50m shotpoint interval per source				Number of Gemini 8K Sources at 37.5m shotpoint interval per source			
		Vessel speed (kt)							
		4.4	4.6	4.8	5	4	4.2	4.4	4.6
Compressor Capacity (CFM)	5400	2	2	2	2	2	2	2	2
	6000	3	3	2	2	2	2	2	2
	6600	3	3	3	2	3	2	2	2
	8000	4	4	3	3	3	3	3	3

Table 1 *Table showing the number of concurrent Gemini 8000 in³ sources that can be hosted by a single vessel on either a 50m inline grid (16.67 m flip-flop-flap, or 25 m flip-flop), or 37.5 m inline grid (12.5 m flip-flop flap, or 18.75 m flip-flop). This is summarized based on testing across several vessels, and assumes typical umbilical dimensions and modern back deck plumbing.*

Conclusions

The geophysical case for the use of single element point sources as the exclusive source on seismic surveys in place of conventional airgun arrays has been made by many authors recently. Not only does this achieve improved low frequency SNR for extended, usable, bandwidth, point source omnidirectionality, and reduce acoustic emissions above the useful seismic range, but results of recent field experience shows that typical, modern survey vessels can host more than just two of these sources. This means that point source configurations can achieve efficiency gains comparable to triple-source airgun surveys that have seen significant uptake over the last decade. Together with the geophysical advantages argued by other authors, this potential for efficiency enhancement help makes a very compelling case to consider the suitability of single element pneumatic point sources as an airgun alternative on modern seismic surveys.

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